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Variants of methods for formation of Mathematical competence and basic competences in science and technology in geography and economics training in the first high school stage

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Abstract: *The study describes the importance of key competences and, in particular, mathematical competence and basic competences in the field of natural sciences and technology for the formation of knowledge, skills and habits in students, with which they are more adaptable to the new educational changes. The main goal of the present work is to present ideas for a model for the formation of Mathematical competence and basic competences in the field of natural sciences and technologies, by using different methods in geography and economics training in the first high school stage.*

Keywords: *mathematical competence and basic competences in the field of science and technology, cartographic competence*

Introduction

There is a clear trend for the competency approach of becoming one of the leading pedagogical concepts, arouses considerable interest and is the subject of debate by all participants in the modern educational process. By using it is expected to achieve greater efficiency in practical pedagogical activity [1].

In connection with its implementation, groups of key competences described in the European reference framework have been formed [8]. The formation and development of these competencies are essential for the formation of socially responsible and motivated citizens of Bulgaria, Europe and the world. The school subject of geography and economics creates excellent opportunities for the formation of the key competences described in the reference framework.

Materials and Methods

The main purpose of the present study is to present ideas for a model for the formation of Mathematical competence and basic competences in the field of natural sciences and technologies, through the use of different methods in geography and economics training in the first high school stage. The research methods used are analysis of literary sources and situational analysis.

Results and Discussion

Theoretical statements

Competency-based education entered the educational systems of some countries as early as the 1990s. The introduction of competencies as expected learning outcomes in education has been one of the most important changes in the education system for many years.

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Increasingly, the educational models of the 21st century require the pedagogical staff to develop and maintain a large number of competences. The profile of the teacher of the 21st century is complex and consists of a large number of characteristics that largely affect the competences he must possess [5]. In order to meet the challenges of his time, the teacher should consider the following principles in his work:

- Training should be learner-oriented and to be personalized;
- -Students to participate actively in the learning process and to use modern technologies;
- To improve in the field of new technologies;
- To have a global view of the world;
- Be smart and use the smartphone as a source of information;
- To use information from blogs;
- To use digital resources;
- To cooperate with students;
- To pay attention to social media;
- To apply training that is based on educational projects;
- To build a positive digital footprint while maintaining professional behavior both in class and online;
- To be an innovator;
- To continue studying [12].

Theoretically, the concept of "competence" can have two characteristics. The first is that competence is consist of the specific behavior on the part of the individual that leads to best performance. The second is that this behavior is associated with the personal qualities that are inherent in a person who is learning and developing. In this sense, competence is a basic ability based on knowledge, experience, values that the person develops through training. The importance of these competences is that they are a prerequisite for life and professional fulfillment, stimulate individuals to self-evaluation, self-development and improvement throughout their life. These skills bridge the gap between different qualification pathways and are transferable to a wide range of applications in the labor market. With the acquisition of these skills and competences the mobility of the workforce and its adaptability to the rapidly changing conditions in the country and the European space will be ensured. [7].

In the debates, the concept of key competences is presented as a move towards the increasing 'convergence' between vocational education and general education based on individual development. Competences are designed to be applied in any professional setting and transcend conventional discipline and subject boundaries. They are said to be essential for effective participation in any field of work. They are general and not specific to the exercise of a particular profession [9].

Key competences play a particularly important role in empowering people vulnerable to unemployment and social exclusion. This is only half of the problem - these people have a low level of education they are outdated or have unmarketable qualifications. In most countries in the European Union, there are various training opportunities for those seeking knowledge with the necessary skills and qualifications. There are people locked in the vicious circle of low level of education, insufficient self-esteem and low motivation to learn. They often do not seek knowledge and are doomed to poverty and social exclusion. Key competences can help them break out of this loop and take advantage of available learning and work opportunities [4].

The introduction of key competences in the training of the various subjects is related to the need of strengthen the connection between the educational system and the needs of business environments and the skills they need. For this purpose, in Ordinance No. 5 on general educational preparation and in the curricula for the various subjects, areas of competence, expected learning outcomes (knowledge, skills and attitudes) and their relationship with individual key competences are described [11].

More important than ever is to Invest in core skills. High-quality education, including extra-curricular activities and a broad approach to developing competences, leads to a higher level of acquired basic skills. In addition, in a society that is becoming increasingly mobile and increasingly digitized, it is necessary to explore new ways of learning. Digital technologies are impacting education, training and learning by developing more flexible learning environments adapted to the needs of a highly mobile society [13].

Public attention is increasingly focused on the results of the educational system. There is a unity between business, the management and the civil sector for the need of education to form competences for successful implementation in students. This unification, as well as the integration of EU recommendations for the development of key competences for lifelong learning, found expression in the Law on Preschool and School Education adopted in 2015. The law regulates the inclusion of the eight groups of key competences described in the European reference framework as part of the general educational preparation indicated in

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figure 1 and adds another ninth - Skills to support sustainable development and a healthy lifestyle and sports [11, 18].

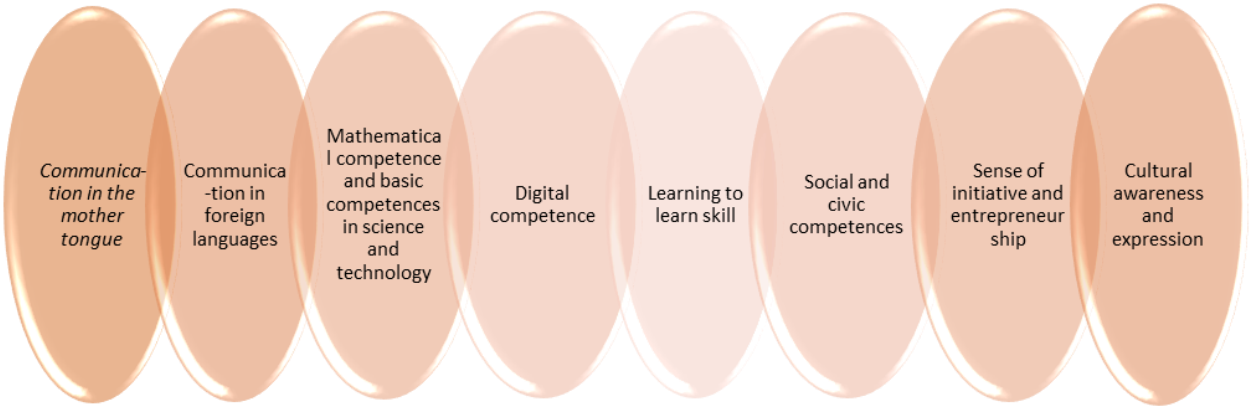

Figure 1. Groups of key competences described in the European reference framework [8]

The framework defines the competences as a combination of knowledge, skills and attitudes, while at the same time defining knowledge as consisting of facts, data, concepts, ideas and theories that are already established and support the understanding of a particular field or subject, skills as ability and opportunity of a person to perform processes and use existing knowledge to achieve results, and attitudes as a disposition and way of thinking for action. Each of the eight key competences is clearly defined and the specific knowledge, skills and attitudes that relate to it are specified [10].

According to the European Commission, key competences are a combination of knowledge, skills, attitudes and values that are particularly necessary for personal realization and development, social inclusion, active citizenship and employment. The development of these competences is a key factor in innovation, productivity and competitiveness and ensures greater flexibility in the workforce, and allows to adapt more quickly to the constantly occurring changes in an increasingly interconnected world. Key competences relate to learning outcomes and refer to what students are expected to know, understand and be able to demonstrate after completing the learning process [6].

As for their development at school, the key competences are cross-curricular and therefore applicable in all subjects and school activities. Therefore, any key competence or all of them together can be developed in each subject. The notion that a given competence, say mathematical, can only be developed in mathematics and physics classes and cannot be developed, for example, in geography and economics classes, contradicts the overall philosophy of the recommendation of EU and the holistic approach to acquiring competences [13].

Each competence includes a combination of cognitive and practical skills, knowledge (including tacit knowledge), motivation, value orientation, attitudes, emotions and other social and behavioral elements that, taken together, can be mobilized for effective action. Each competency is related to performing a given task in a given context, so competences can be acquired in the process of solving a particular task [15].

With the development of technology and the growing importance of forecasting skills needs, the terminology in vocational education has also evolved, with an increasing emphasis on skills as a general concept. Research shows that the demand for people with technological skills (programming and IT skills), social and emotional skills and "soft skills" (entrepreneurship, initiative, leadership, people management) and high cognitive skills (creativity, critical thinking, processing and analysis of information) grows at the expense of people with mostly basic cognitive skills (data collection and processing, calculations) and with physical and manual skills (manual machine operation, repair, technical skills). However, once acquired competences have their own life cycle and if they are not maintained and improved constantly - throughout life, they gradually „fade out“[3].

Three challenges have been identified to support competence-based education, training and learning in the context of lifelong learning:

- the use of diverse approaches and contexts for learning;
- help for teachers and those working in the education system;
- and assessment and validation of competence development [9].

Eurydice's report highlights that only three of the competences, namely communication in the mother tongue, communication in foreign languages and basic competences in mathematics, science and technology

are common and assessed in national tests. In contrast, in many European countries, other basic competences such as the learning to learn skill or social and civic competences are not formally assessed. Competences assessed less often are digital competence, learning ability, social and civic competences, initiative and entrepreneurship skills and cultural awareness [4].

Exactly 10 years after the Recommendation of the European Parliament and the Council of Europe for the integrated development of key competences for lifelong learning, the Preschool and School Education Act came into force in Bulgaria. It states that key competences must be „covered by general education". Thus, the Law on Preschool and School Education becomes one of the most direct conduits from strategic documents, through a normative framework, to practice. We can also define it as the most large-scale in terms of possible effect - over 800,000 children fall into the education system (school and kindergartens) [18].

Mathematical competence and basic competences in the field of natural sciences and technologies

Understanding and analyzing specific information, the skills to draw conclusions that go beyond the specific fact, thesis or concept are skills and competences of particular importance for learners and are formed through mathematical competence and basic competences in the field of natural sciences and technologies [14].

We accept mathematical competence as the ability to develop and apply mathematical thinking to solve a range of problems in everyday situations. It includes the ability to use mathematical ways of thinking by applying logical and spatial thinking and presenting the final result through graphic images such as formulas, models, graphs, diagrams.

Mathematical competence is closely related to the ability to use numbers, basic operations, symbols and forms of expression and mathematical logic to interpret information about quantitative and spatial aspects of reality and to solve problems that are relevant to everyday life. Some of the mathematical skills are broader and include the ability to interpret and express information accurately and to present concrete arguments. In this way, through the formation and application of mathematical competence, it is expected to increase the real possibility of continuing learning throughout life and to promote the future effective participation of learners in public life [14]. Therefore, one of the reasons for the need to form mathematical competences is the possibility of their practical application in real life.

Mathematical competence is defined in a similar spirit, according to the European reference framework for key competences, where the main emphasis is placed on the skills and attitudes for the practical application of mathematics (table. 1).

Table 1. Basic knowledge, skills and attitudes related to Mathematical competence and basic competences in the field of natural sciences and technology according to the European Framework of Reference for Key Competences

Mathematical competence and basic competences in the field of natural sciences and technologies	
Knowledge	• *Good knowledge of numbers and units of measurement and ability to use them in various everyday situations, basic calculation methods, knowledge of elementary forms of mathematical representation - graphs, formulas, statistics.* • *Good knowledge of mathematical terms and concepts, including relevant theorems in geometry and algebra. Understanding and knowing the questions that mathematics can answer.* • *Knowledge of basic principles in nature, in technology and technological products and process.* • *Understanding the relationship between technology and other fields: scientific progress (e.g.in medicine), society (values, morals), culture (e.g., media) or the environment (pollution, sustainable development).*
Skills	• *Ability to handle the basic elements of mathematics, such as addition and subtraction, multiplication and division, percentages and ratios, units of measurement in order to solve everyday problems, such as household budget management (income-expenditure, expenditure planning, savings); shopping (comparing prices, knowing the units of measurement and the value of money); travel and leisure (ratio of distance and travel time; exchange rates and prices).*

	• *Ability to handle mathematical symbols and formulas, decipher and interpret mathematical language and discover its relationship with natural language. Ability to communicate in mathematical language.* • *Mathematical-logical reasoning ability (mastering mathematical reasoning models: abstract and large-scale thinking, creating mathematical models (e.g., analysis and modeling) by using and applying existing models according to the situation.* • *Ability to present the results and reasoning that led to them.*
Attitudes	• *Using calculus methods to solve everyday problems.* • *Readiness to accept or reject the claims of others based on acceptable (or not) arguments or evidence.* • *Interest in science and technology, incl. to safety and security issues as well as ethical issues* [8].

With the basic competences in natural sciences and technologies, we associate the ability and desire to use the body of knowledge and scientific methods to explain processes and phenomena by asking questions and searching for answers, formulating conclusions and applying concrete evidence. These include the understanding of the changes caused by human activity and the acceptance of responsibility by all of humanity and the individual as a citizen of the world.

Variants for the formation of mathematical competence and basic competences in the field of natural sciences and technologies

The school subject Geography and Economics is studied in general educational preparation from 5th to 10th grade (in the compulsory preparation of junior high school and first high school stage), forming specific key competences described in the curricula. The competences for knowledge, skills and attitudes defined by the SAS are composed by degrees and stages of education, specific learning objectives in the relevant stage, degree and areas of competences, expected learning outcomes and their relationship with the individual key competences.

In the school subject Geography and Economics, the formation of mathematical competence can be realized by solving calculation tasks for scale, analyzing different types of diagrams and other types of graphic images, making graphic statistical images, etc.

The formation of cartographic literacy is of great importance in the process of geography and economics training. It is closely related to mathematical competence and is an essential element of the geographical culture for orientation and reasonable action in the geographical space of the students.

Cartographic literacy, as an educational product and a personal intellectual achievement, presupposes the ability and willingness to use cartographic resources for orientation in space and for orientation on the map, for knowledge of the geographical space and for its modeling with the means of cartography. As an international language of communication, it implies mastery of the cartographic conceptual apparatus in a necessary and sufficient minimum and includes the skills to read a map, determine routes and create cartographic images of varying degrees of complexity [2].

Mastering skills for creating cartographic images in a necessary and sufficient minimum is the purpose of secondary education - as a component of geographical culture and part of the general culture of the individual. The formation of cartographic literacy, mathematical competence and basic competences in the field of natural sciences and technologies can be realized through the use of different methods and in different lesson units throughout the course of study.

Education in geography and economics in the first high school stage contributes to the formation of the main key competences of the European reference framework, facilitating the development of coping skills when problematic situations arise [11, 16, 17].

As we emphasized in the theoretical statements, the key competences are interconnected and their formation and development are the purpose of the educational content and the activities related to its acquisition. In the geography and economics curricula in 8th, 9th and 10th grade, described by the National Education and Training Plan, a large number of activities related to the formation and development of the nine key competences, including mathematical competence and basic competences in the field of natural sciences and technologies, can be found [16, 17, 18]. The formation of mathematical competence and cartographic literacy can be realized through the use of different techniques and in different lesson units.

The curricula in geography and economics in the first high school stage are tailored to the needs of the students and provide the opportunity to use various methods through which mathematical competences and basic competences in the field of natural sciences and technologies can be formed.

A good content basis for the formation of mathematical competence can be found in a large part of the units studied in geography and economics in the 8th, 9th and 10th grades.

The topics studied in the 8th grade are suitable for realizing the set goals. The main reason for this is that natural geography is studied in the 8th grade, the ideas of which are directly related to mathematical competence and competences in the field of natural sciences and technologies.

Realization of the set goals is possible in the following units of the Geography and Economics curriculum for the 8th grade:

- Rotation of the Earth;
- Earth's Planetary Movements and the consequences for Our Lives. Time Zones;
- Atmosphere – Composition and structure
- Evaporation, Humidity and precipitation;
- Atmospheric circulation;
- Properties of waters in oceans and seas;
- Movements of water in oceans and seas [16].

Already in one of the first lessons studied, "Planetary movements of the Earth and the consequences for our lives. Time Zones" we find opportunities for the formation of mathematical competences and basic competences in the field of natural sciences and technologies. Since this topic is set as an activity lesson, we can use a method that requires more school time - game simulation method of training. For this purpose, students are divided into 4 teams of 6 people. The teacher has previously prepared cards on which cities from different parts of the Earth are written (Fig. 2). The students are given the following task: Calculate the time difference between the two cities, draw up a travel route by describing the major airports you will pass through (it is a condition that you write down only the airports where you will land during the day), describe the countries you pass through and interesting in your opinion tourist sites in them and finally describe the agricultural crops that the natural conditions in the given country allow to grow.

Figure 2. Cards for the game „Calculate the time difference“

When playing the game, the 40 minutes of study time was well distributed by the students. The students divided the tasks within the teams themselves.

Figure 3. Student answers to the game „Calculate the time difference“

All teams thought that calculating the time difference took the least time, so they designated one person for this activity, who is also the speaker of the group. They chose two people to determine their airports, to determine the countries through which will pass - 1 student, and the remaining three of the team determined the tourist sites and agricultural crops. Figure 3 shows part of the responses of two of the teams.

The reasons for choosing and using the game as a method are: the possibility of introducing competition and a competitive element; enjoyment of the activity itself with a competitive element; overcoming certain limitations in group communication; developing communication skills, etc.

He methodological requirements for the implementation of the assigned task are described in Figure 4. Through the assigned task, the students develop teamwork skills, evaluation and self-assessment, reading skills and map orientation, as well as abstract and analytical thinking skills. Students also develop their skills in handling geographical sources of information, ICT and above all their speaking skills.

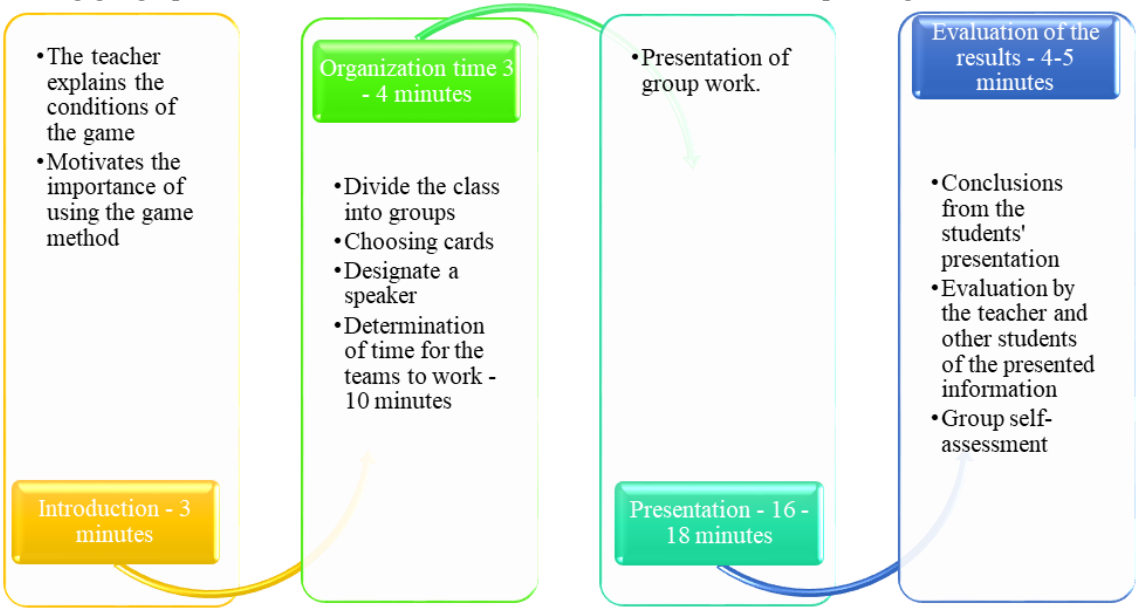

Figure 4. Key moments in the implementation of the game „Calculate the time difference“

Other variants of activities that we believe are suitable for the formation of mathematical competences and basic competences in the field of natural sciences and technologies are related to the creation and analysis of diagrams, cartograms and climatograms, hydrograms, etc.

In the 9th and 10th grade there are a large number of topics that are suitable for applying different methods and for the purpose of forming mathematical competences and basic competences in the field of natural sciences and technologies. Table No. 2 presents some of them.

Table 2. Units from the curriculum in geography and economics for grades 9 and 10, which are suitable for the formation of mathematical competences and basic competences in the field of natural sciences and technologies

Geography and economics for 9th grade	Geography and economics for 10th grade
• Number, distribution and movements of population around the world • How the Earth's population is changing • World economy in value and natural indicators • World trends in energetics development • International economic relations. Trade and tourism • Region of Asia	• Geographical location, borders and size of Bulgaria • Natural resources in Bulgaria • Climate of Bulgaria • Waters of Bulgaria • Population structure of Bulgaria • Agriculture of Bulgaria • Tertiary sector. Transport • Southwest region

When studying the topic World trends in the development of power generation in the 9th grade, students are given the following task: Make a pie chart reflecting the distribution of energy resources used to produce electricity in the world today. Search for information on resources used in 1980. Make a pie chart. Compare the two diagrams and draw conclusions.

The purpose of the task is to develop students' skills for critical thinking, logical reasoning, analysis and evaluation of information and practical application of knowledge. During its implementation, the students formulate conclusions about the influence of energy and the used energy resources on the environment, which also develops their ability to apply the principles of sustainable development and acquire competences for understanding global processes, trends and their relationships.

Conclusions

Based on the above, we can summarize:

- The formation of mathematical competence and basic competences in the field of natural sciences and technologies is possible during the study of a large part of the topics laid down in the curricula of geography and economics in the 8th, 9th and 10th grades, because this is regulated in the regulatory framework.

- The application of mathematical logic and the use of geographical means to present information supports the formation of mathematical competence and basic competences in the field of natural sciences and technologies in students.

- The formation of students' mathematical competence and basic competences in the field of natural sciences and technologies leads to the mastery of widely applicable skills to defend their own position on issues relevant to society, to present their own ideas by developing original and critical thinking.

- The skills to describe data and their mathematical interpretation through relevant diagrams, cartograms and others gives students self-confidence to realize the relationship between nature – society and man and contributes to enriching their mathematical competence, their sense of initiative, their social skills.

- The formation and development of the ability to apply mathematical competence and basic competences in the field of natural sciences and technologies among students in the course of geography and economics training of the secondary school is a complex and continuous process that begins in the junior high school stage, goes through the course of study, consolidates in the high school stage and continues throughout life.

- Variants of methods for forming mathematical competence and basic competences in the field of natural sciences and technologies in students' geographical education at secondary school are diverse and are related to the educational content, material provision, the specificity of the students' cognitive abilities and their individual characteristics, as well and the creative pursuits of the geography teacher.

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